Crustal Clues: Investigating Seafloor Spreading

STUDENT NAME: .....

STUDENT ACTIVITY

SCIENTIFIC OCEAN DRILLING

Objective(s)/Outcome(s)

Students will be able to plot and analyze data taken from ocean floor drill sites during Expedition 168 to describe evidence of seafloor spreading.

Materials

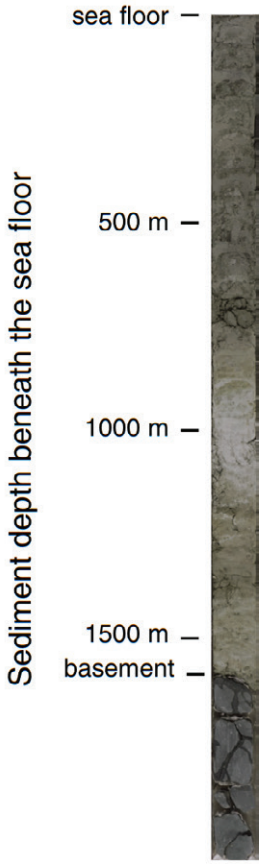
- copy of data table
- copy of Figure 1 and Cross-Section Sheets
- tape
- colored pencils
- ruler
- computer with internet access (optional)

Background

The goal of scientific ocean coring is to investigate the sediments and rocks beneath Earth's oceans and seas, which give insight into Earth's history. The seafloor is made up of layers of sediment on top of oceanic crust. This sediment is frequently composed of sand, silt, clay and microfossils that drift down through the water. This sediment layer can be up to 2000 meters thick depending on the location (see Figure 1). The oceanic crust that is the basement rock below seafloor sediment is most frequently basalt that forms when magma from the Earth's mantle erupts at mid-ocean ridges and hotspots.

Mid-ocean ridges are divergent boundaries that separate tectonic plates. On average, tectonic plates on either side of a mid-ocean ridge move a few centimeters a year. New ocean floor is created at mid-ocean ridges and slowly moves outwards. This is called seafloor spreading. Sediment accumulation (deposition) on the seafloor near mid-ocean ridges can be used as evidence of the movement of these plates. Data on seafloor sediment is collected by expeditions conducted by scientific vessels such as the *JOIDES Resolution* (*JR*). In the summer of 1996, scientists on board the *JR* collected sediment core samples at 10 sites east of the Juan de Fuca mid-ocean ridge, off the coast of Washington State. This data can be used to understand the direction and rate of movement of the Juan de Fuca Plate.

FIGURE 1. OCEAN SEDIMENT CORE SHOWING BASEMENT ROCK COVERED IN LAYERS OF SEDIMENT



Credit: Modified from ODP, Expedition 168

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Activity

1. Study Figure 2, the map of drill sites on the Juan de Fuca Plate (Expedition 168). Discuss with your group where you think the mid-ocean ridge is on this map. Why do you think this?

2. Using the key in Table 1 and the data in Table 2, color each drill site point on the Expedition 168 drill site map.

TABLE 1. COLOR KEY FOR AGE OF DRILLING SITES

Color	Age of Basement Rock at Drill Site (Ma)
Red	0–0.99 Ma
Yellow	1–1.99 Ma
Blue	2–2.99 Ma
Green	3–3.99 Ma

3. Use the data in Table 2 to create a cross-section of the seafloor sampled during Expedition 168:

   a. Data is given for the mid-ocean ridge but note that this was not a drill site during Expedition 168.

   b. "Water depth" indicates the distance (in meters) from the water's surface to the seafloor at each site indicated.

   c. "Depth to basement rock" indicates the distance between the seafloor and the top of the basement rock (in meters below seafloor, mbsf). This is a measurement of the thickness of sediment that has deposited on basement rock at each site.

   d. Line up the top edge of the provided Cross-Section Sheet with the bottom edge of the paper with Figure 2 and tape the edges of these papers together.

   e. On the Cross-Section Sheet, plot the water depth of the mid-ocean ridge and each drilling site. Use a ruler to make sure the data lines up with the appropriate site on Figure 2.

   f. Calculate the depth to basement rock in meters below sea level so it can also be plotted on the same Cross-Section Sheet.

4. Connect the water depth points using a ruler. Start at the point for the mid-ocean ridge and connect it to Site 1023, then continue until you have estimated the depth of the seafloor.

   a. Shade the entire space above this line up to the top of the x-axis (0 meters) blue. This area is the ocean.

   b. The line you drew represents the seafloor. Label this line "seafloor."

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5. Using a ruler, connect the plotted points of the basement rock, starting at the mid-ocean ridge.
   a. This line is the top of the basement rock level, where basalt first appeared in core samples from Expedition 168.
   b. Shade the entire space below the top of the basement rock line to the bottom x-axis of the cross-section gray. This new shaded area is the basement rock, basalt.
6. Shade yellow the space between the seafloor line and the top of the basement rock line. This shaded area is the sediment.
7. Fold your paper where you taped the two pages together.
   a. Hang this sheet at the edge of a table so the Map view of the Juan de Fuca plate is flat on the table, and the cross-section view hangs off the side of the table.

Analysis

1. Use evidence from the seafloor cross section you made to describe how the seafloor, sediment, and basement rock differ as you move from the mid-ocean ridge to the east.

2. On your cross-section, you estimated the shape of the seafloor by drawing straight lines between the coring sites. How well do you think this represents the actual shape of the seafloor? Why do you think this?

   a. Obtain a figure of the seafloor from your teacher. This was created using data from Expedition 168, in addition to other data taken in the area. Describe how the shape of the differs from your cross-section.

   b. Use evidence from this new figure to explain why it is important to collect many data points when studying the seafloor.

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Synthesis

1. Sediment thickness on the ocean floor can be used to determine the direction of movement of tectonic plates on either side of a mid-ocean ridge. Which cardinal (N, E, S, W) or ordinal (NE, NW, SE, SW) direction best describes the direction of movement of the plates cored during Expedition 168? Explain your reasoning.

2. Imagine you are on the newest IODP expedition, and you want to drill additional core samples in this area. Choose 2 new sites, and label them “Site A” and “Site B”. Explain why you chose these sites and what you would expect to find out about the sediment thickness and depth to the basement rock in these locations.

Extensions

1. Research another type of data that scientists collected from the Juan de Fuca drill sites. What did this data reveal about the seafloor in this area?

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HANDOUTS

TABLE 2: DRILL SITE DATA

EXPEDITION 168

Location	Age of Seafloor (Ma)	Water Depth (meters to sea floor)	Depth to Basement Rock (mbsf)	Depth to Basement Rock (meters below sea level)
Mid-Ocean Ridge	0	2100	0	
Site 1023	0.86	2593	192	
Site 1024	0.97	2613	159	
Site 1025	1.2	2609	99	
Site 1026	3.5	2658	238	
Site 1027	3.6	2657	575	
Site 1028	1.6	2659	132	
Site 1029	1.9	2653	220	
Site 1030/1031	1.4	2595	44	
Site 1032	2.6	2645	290	

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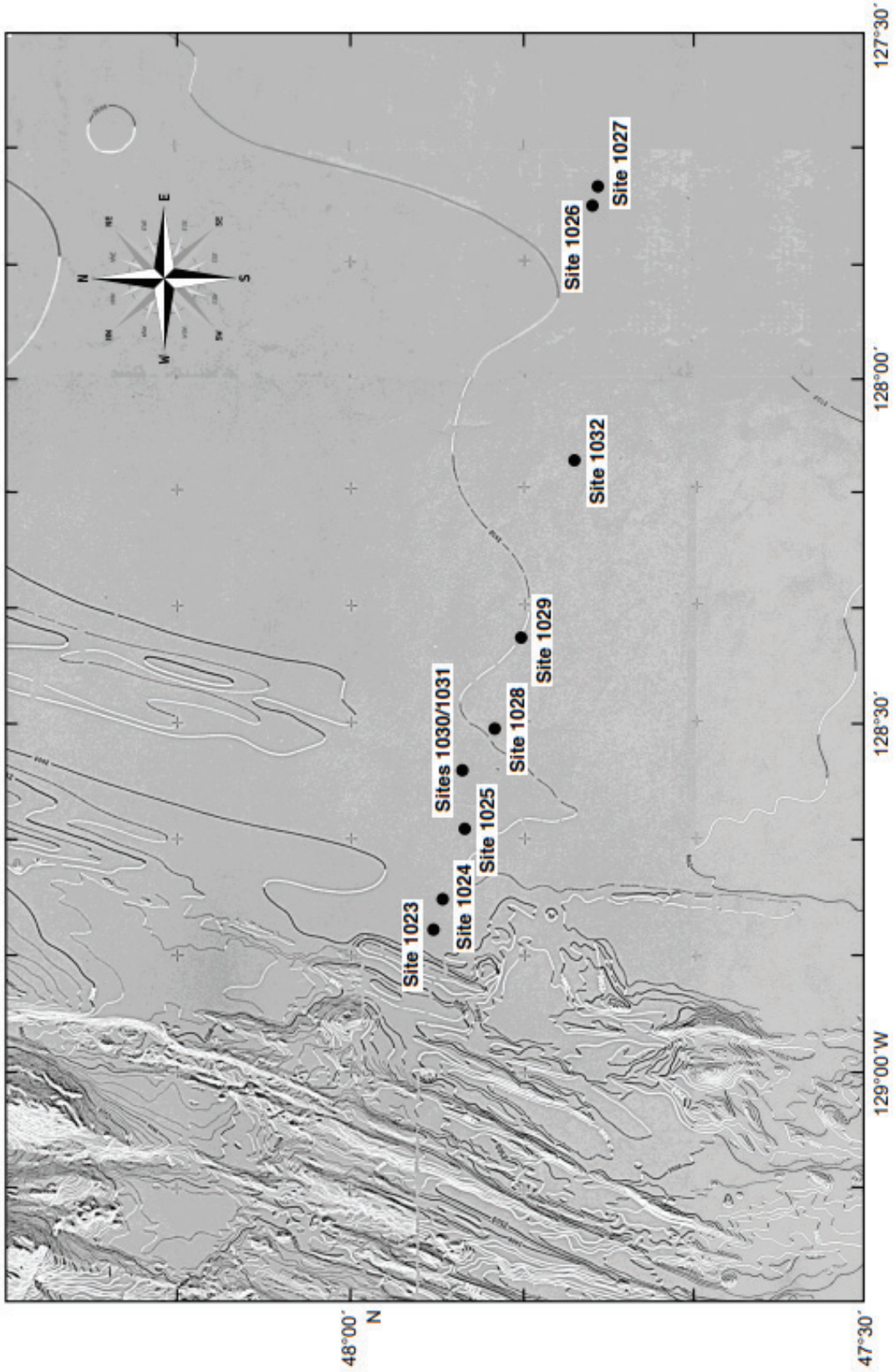
FIGURE 2. MAP OF DRILL SITES FROM EXPEDITION 168



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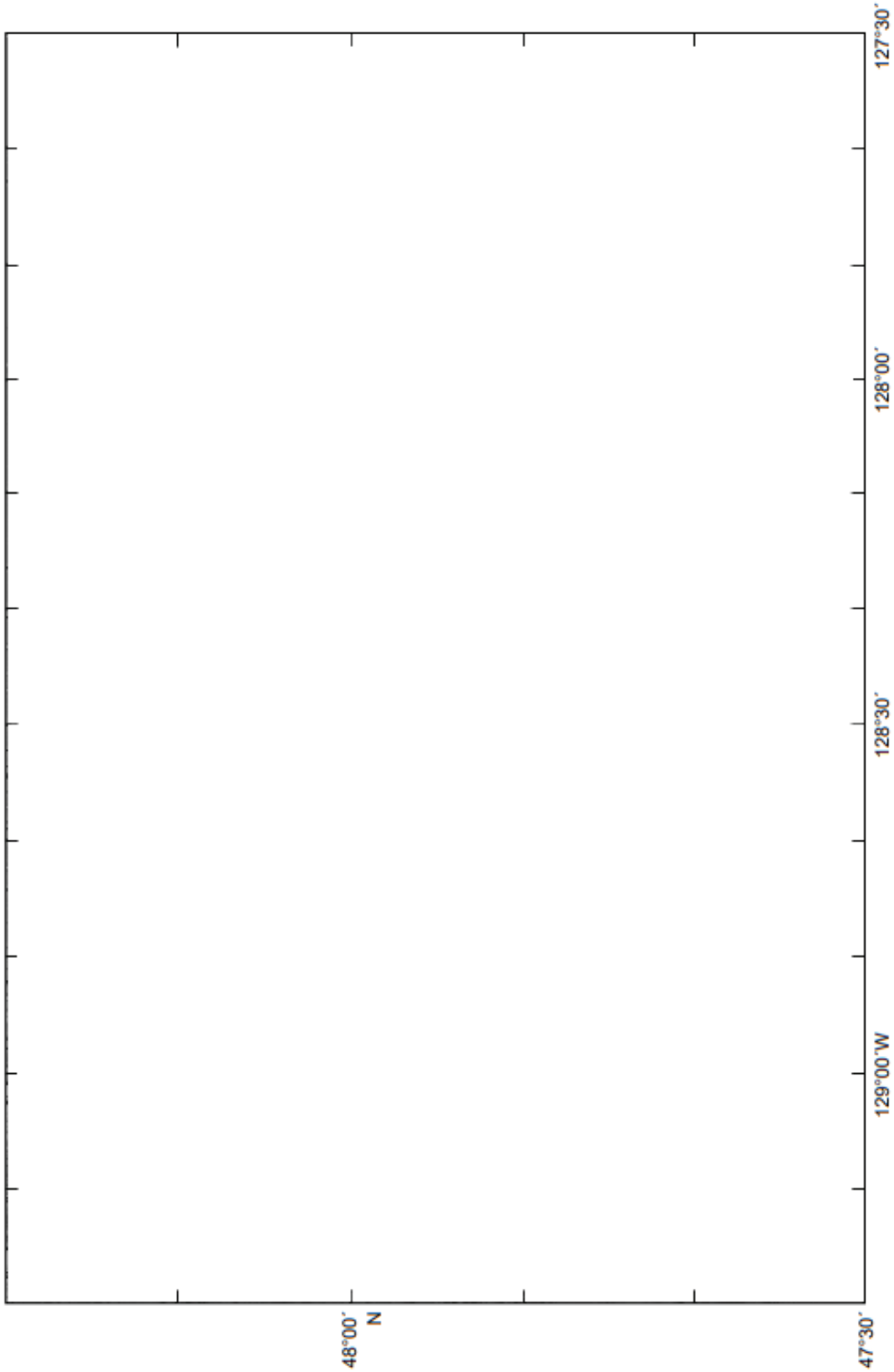
CROSS-SECTION SHEET